

Some Electric Vehicle Charging Basics

Electric Vehicle Supply Equipment, (EVSE), is considered by the National Electrical Code to be a continuous load, which means the supply system to the equipment must be rated for 125% of the nameplate rating.

Level 1 charging is very simple and consists of a basic extension cord from a 120 volt receptacle. The inverter/charger is on board the vehicle, and the rating is determined by the design of the charger. Maximum power allowed for a 20 amp, 120 volt EV charger would be 1920 watts, (16 amps x 120 volts). A load of this nature could not be effectively served by a 15 amp, 120 volt circuit.

Level 2 charging at a higher power transfer rate will shorten the time it takes to achieve a full charge of the EV batteries. A major concern for level 2 charging equipment is that the make and break contacts for connection of the power supply can safely handle the current flow.

NEC article 625 contains provisions to prevent making or breaking the connection under load. The long awaited SAE standard J1772 for the connector configuration has not been finalized as of November, 2009. The anticipated rating of this connector has been reported to be as much as 70 amps at 240 volt. It is likely that EVSE will be manufactured in a variety of voltage and current ratings. Here are some combinations that will meet the requirements of the NEC;

- 1) 30 amp 240 volt single phase equipment could deliver 5760 watts
- 2) 40 amp 240 volt single phase could be rated for 7200 watts
- 3) 50 amp 240 volt single phase could go as high as 9000 watts
- 4) 60 amp 240 volt single phase would be limited to 11,520 watts
- 5) 70 amp 240 volt single phase could deliver power at 13,440 watts

Each of these configurations meets the requirement that the equipment does not exceed 80% of the capacity of the supply circuit. In other words, the supply circuit and system are rated at 125% of the equipment as required for a continuous load.

The higher the rating, the shorter will be the time to reach full charge for a depleted EV battery pack. One challenge for EVSE and inverter/charger design is for these two pieces of equipment, (on board charger, and EVSE), to be able to communicate with each other to determine charge rate capability. Another piece of crucial information is that the J1772 connector is fully engaged, and the EVSE contactor can close and begin delivery of power to the vehicle. There must also be a provision for the contactor to open and de-energize the connector and cord if they are subjected to strain, (like if someone tries to move the vehicle before disconnection of the cord, 625.19).

Simply stated, the sequence of operation is that the connection of EVSE to the onboard charging equipment establishes communication, determines rate of charge capability, and controls the delivery of energy to the on board EV battery charging system.

On board inverter/charger equipment needs to be flexible and versatile to accommodate different voltage and charge rate configurations of EVSE. Most dwelling based charging equipment will probably not exceed 7200 watts, while fast charging, commercial “fueling” stations may be as high as 13,440 watts for level 2 charging. Again, the higher the charge rate, the shorter the duration to full charge.

The J1772 connector configuration is expected to consist of three power “pins” of high capacity, and two communication pins. One high capacity pin must be dedicated to grounding and bonding between the EVSE and the vehicle to prevent shock hazard. This configuration does not allow the application of 3 phase power delivery to an on board charger.



High Capacity 3 phase supply will likely become the standard for Level 3 EV charging equipment. This standard will be quite different in that the inverter / charger equipment is off board and delivers DC power to the vehicle.

Some History of EV Charging in Oregon

It became apparent in 2008 that electric vehicle technology had advanced to the point that practical vehicles would be readily available in about 2 years. Proponents of electric vehicles have very clearly indicated that construction of a public and private EV charging infrastructure would be a key component to the successful use of electric vehicles.

Level 1 EV charging stations have been built and evaluated for safety by several equipment manufacturers. Level 1 charging is comparable to plugging in an electrical appliance, and can be as simple as a 20 amp, 120 volt GFCI protected receptacle in an enclosure suitable for the environment of its location. The limited rate of energy transfer to EV batteries translates into a charging duration of 8 to 14 hours to reach a point of full charge.

The Oregon Electrical Safety Law, and the 2007 Fire Code adopted by Oregon both contain a requirement for electrical products and electrical appliances to be evaluated for safety and listed or certified by a testing laboratory. In September of 2008, the Oregon Building Codes Division adopted the following administrative rule to make it clear to inspecting authorities throughout the state that a special deputy certification label would satisfy this requirement.

OAR 918-311-0065

Electric Vehicle Charging Station Statewide Permit and Inspection Protocol

To ensure a path for the emerging technology and enable the installation of charging stations for electric vehicles, the following permit and inspection protocols will apply throughout the state, notwithstanding contrary provisions contained in the **Oregon Electrical Specialty Code**.

- (1) Building officials and inspectors shall permit and allow installation of an electric vehicle charging station that has a Building Codes Division's special deputy certification label without further testing or certification.
- (2) Persons installing an electric vehicle charging station must obtain a permit for a feeder from the inspecting jurisdiction. No other state building code permit is required.
- (3) The jurisdiction may perform up to two (2) inspections under the permit issued in subsection (2) above.
- (4) Inspection of the installation is limited to examining the feeder for compliance with the following **Oregon Electrical Specialty Code** provisions:
 - (a) Overcurrent protection, per articles 225 and 240;
 - (b) Physical protection of conductors, per article 300;
 - (c) Separation and sizing of the grounding and neutral conductors, per article 250.20; and
 - (d) Provisions for locking out the breaker for maintenance, per chapter 4.

(5) For the purpose of this rule, the service, feeder, and charging station pedestal will be considered a single structure as defined by the **Oregon Electrical Specialty Code**. The structure's owner may opt to install a grounding electrode system to supplement lightning protection, but cannot be required to do so.

Stat. Auth: ORS 455.065

Stat. Implemented: ORS 455.065

Hist.: BCD 16-2008(Temp), f. & cert. ef. 9-26-08 thru 3-25-09; BCD 30-2008, f. 12-31-08, cert. ef 1-1-09

The National Electrical Code, NFPA 70 adopted by Oregon contains a requirement for any structure served with electricity to have a grounding electrode system installed. OAR 918-311-0065(5) identifies the service, feeder, and charging station pedestal as a single structure, effectively exempting the pedestal from the requirement for installation of a grounding electrode system. Item (4)(c) of the rule clearly requires a separate and properly sized equipment grounding conductor routed with the feeder conductors. This is similar to the statewide interpretation regarding pedestals for Recreational Vehicles in RV parks.

Developers and property owners started considering the value of adding provisions for electric vehicle charging stations in the design for parking structures. Electrical engineers and contractors started considering the electrical services and feeders needed to supply the anticipated EVSE.

A hypothetical scenario was presented to the division as follows; A parking structure developer would like to provide electrical capacity in the structure for 10 EVSE units consisting of level 1 and level 2 charging stations. Each unit would total 100 amps at 240 volts, and the service calculation dictated the installation of a 1,000 amp service. The electrical contractor speculated that the calculation might even have to be increased to 125% for continuous load, pushing the size of the service equipment to 1600 amps, (the next standard size over the calculated minimum of 1250).

The electrical section of the division started researching battery charge rate data and the concept of load diversity. It was discovered that the charging current curve for Lithium Ion, and Nickel Metal Hydride batteries is significantly different from that of lead acid batteries.

Charge rate data from industrial facilities that use electric fork lifts with lead acid batteries was collected, and the load readings on the overall service equipment revealed that even peak load times did not approach the full rating of the equipment. However, there is no data available for multiple Lithium Ion and Nickel Metal Hydride charging units, as there are no operating facilities in existence.

Code articles that are associated with installations of similar electrical utilization equipment contain demand factor tables for multiple units. These tables are evident in article 550 mobile home parks, 551 RV parks, 555 boatyards and marinas, and 626 electrified truck parking. In September of 2009 the division approved an alternate method ruling to allow the use of a demand factor table for calculating the minimum ampacity for feeders and services that supply EVSE. This demand factor table is similar to the table that applies to power provisions for floating structures in marinas and boatyards, table 555.12.

All users of the NEC should recognize the purpose statement in article 90.1 indicating that the provisions therein are considered necessary for safety. Compliance with these provisions does not guarantee that the installation will be efficient, convenient, or adequate for good service or future expansion of electrical use. Nor is it the intent of the *Code* to be a design specification or instruction manual.

State of Oregon
Building Codes Division
Contact: Dennis Clements, Electrical Program Chief
(503) 378-4459 or dennis.l.clements@state.or.us

Statewide Alternate Method No. OESC 09-01
(Ref.: ORS 455.060)

September 24, 2009

Approval of the use of a demand factor table for calculating Electric Vehicle
Supply Equipment services and feeders

Statewide Alternate Methods are approved by the Division administrator in consultation with the appropriate advisory board. The advisory board's review includes technical and scientific merits of the proposal. In addition:

- *building officials shall approve the use of any material, design or method of construction addressed in a statewide alternate method,*
- *the decision to use a statewide alternate method is at the discretion of the designer,*
- *statewide alternate methods do not limit the authority of the building official to consider other proposed alternate methods encompassing the same subject matter*

Initiated by: The Building Codes Division

Applicable Code Section: NEC Article 625

Background:

This alternate method allows electrical contractors to apply a demand factor to services and feeders that supply Electrical Vehicle charging stations.

The electrical code provides demand factor tables for installations of similar equipment, such as Mobile Home Parks, Recreational Vehicle Parks, Marinas and Boatyards, and Electrified Truck Parking Spaces.

Procedural and Technical Discussion:

Under Oregon law, when the division considers making an alternate method ruling as a method of construction, it must consider “standards and interpretations published by the body that promulgates any nationally recognize model code adopted as a specialty code of this state.” ORS 455.060.

Article 625 states that electric vehicle charging loads are considered a continuous load. However, the electrical code provides demand factor tables for installations of similar equipment. This article does not contain any provisions to apply a demand factor or consider load diversity for services and feeders that supply multiple charging stations. Studies performed while monitoring battery charging processes demonstrated that peak current draw did not exceed 50% of rated loads. The level of charging required for individual battery modules varied widely. For these reasons, application of a demand factor is justified by the technical substantiation.

Technical and Scientific Findings:

As approved by the Oregon State Electrical and Elevator Board, the following technical and scientific facts apply to the installation of services and feeders that supply electrical vehicle charging equipment:

- Considering EV charging equipment continuous loads assumes that all charging equipment is likely to operate at full rated load for three hours or more.
- Testing data shows that charging currents are substantially below the full rated load and that cycle times typically do not exceed three hours.
- The provisions of this Statewide Alternate Method ruling bring the language of article 625 into alignment with other similar articles, 550, 551, 555, and 626.
- A demand table is an appropriate method of calculating loads on services and feeders.

Scope of Ruling:

This ruling addresses the installation of electrical equipment supplying electric vehicle charging equipment. The acceptability of using the demand factor table to calculate loads for electric vehicle charging stations as an alternative to assuming a continuous load is contingent on meeting the following conditions:

1. Except as otherwise provided for in this alternate method, the provisions of the Oregon electrical specialty code shall be applicable to all installations of electric vehicle charging equipment.
2. All provisions for enclosure integrity, conductor ampacity, and overcurrent protection in chapters 1 through 4 are met.

3. Load calculations for services and feeders that supply electrical vehicle charging equipment shall be permitted to be modified as indicated in notes (1) and (2) to the following table:

Table 625.14

Demand Factors

Number of EVSE stations	Sum of EVSE station ratings (%)
1-4	100
5-8	90
9-14	80
15-30	70
31-40	60
41 plus	50

Notes:

1. Where EVSE stations consist of a combination of level 1 and level 2 provisions, (for example, two 30 ampere, 240 volt circuits feeding two separate J1772 electric vehicle connectors and one 20 ampere, 125 volt circuit feeding a GFCI duplex receptacle), the demand factors in table 625.14 shall be permitted for each service and/or feeder supplying the multiple supply stations.

2. Where multiple EVSE stations consist of a single level 2 electric vehicle connector, and the demand factor of Table 625.14 are applied, the demand factor specified in 220.61(B) shall also be permitted.

Conclusion:

After considering the technical and scientific approval by the Oregon State Electrical and Elevator Board, the division rules that applying demand factors to the installation of electric vehicle charging supply systems are acceptable as a construction method, subject to stated limitations, and Alternate Method Ruling No. OESC 09-01 is approved.

While the J1772 standard is yet to be released, and the actual configuration of EVSE is yet to be seen, tools and guidelines for regulating electrical installations associated with this equipment are needed. The following is an example of the application of the above mentioned alternate method ruling;

An equipment manufacturer develops and builds a dual station enclosure that contains provisions for two 30 amp 240 volt EV charging stations. A parking structure developer purchases 18 of these units and hires an electrical contractor to design and install an electrical service and distribution system to supply the equipment. A logical and code compliant approach to the design might look like this;

The demand factor table can be applied to feeders that serve more than 4 charging stations. A demand factor of 90% can be applied to six 30 amp stations.

Group the units by threes, and provide a feeder to each group;

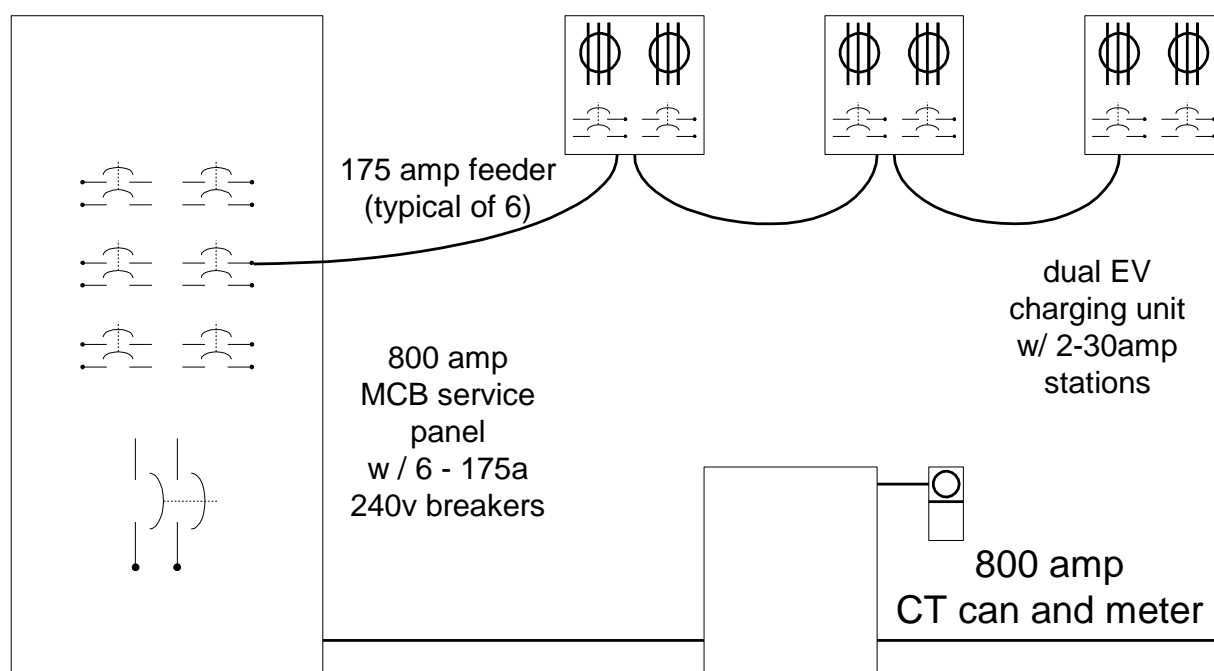
6 charging stations x 30 amps each x .9 = 162 amp minimum feeder size

If the units are equipped with in and out terminal blocks rated for 75° C, 2/0 copper THHN conductors could be used to supply each group of three dual stations. Each of the 6 feeders would be protected by a 175 amp breaker.

The overall service could be calculated as follows;

36 charging stations x 30 amps each x .6 demand factor = 648 amp minimum

The next standard breaker size is 700, however an 800 amp service would probably be installed, (more readily available). All feeder and service entrance conductors are adequately protected by overcurrent devices.



Without the demand factor table the minimum calculated rating of the service would be 1080, dictating the installation of a 1200 amp service.

Demand table application to other configurations of multiple units of EVSE may pose even more dramatic reductions in the overall size of service equipment. Again, this *Code* contains provisions that are considered necessary for safety. Compliance therewith and proper maintenance will result in an installation free from hazard but not necessarily efficient, convenient, or adequate for good service or future expansion of electrical use, nor is it intended to provide design specifications.